

The strategy for conservation and sustainable utilization of biodiversity in Changbaishan Biosphere Reserve¹

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Abstract This paper is focused on ecological assessment of the status of bio-diversity, and a strategic plan for bio-diversity conservation on a sustainable basis. It described the present situation, the causes of bio-diversity degradation, and the approaches for conserving, utilizing and developing bio-diversity in Changbaishan Biosphere Reserve.

Key words: Strategy, Conservation, Sustainable utilization, Changbaishan Biosphere Reserve.

Introduction

Due to the soaring increase of the population, along with the increase of consumption, and the mismanagement of biological resources as well as many other social economic and institutional constraints, today's threats to species and ecosystems are the greatest in the recorded history. The conservation of bio-diversity becomes an urgent task that we are facing now. In order to accelerate conservation of bio-diversity on a sustainable basis in Changbai Mountain areas, this study was conducted. This paper is focused on ecological assessment of the status of bio-diversity, and making a strategic plan for bio-diversity on a sustainable basis. It described the present situation, the causes of bio-diversity degradation, and the approaches for conserving, utilizing and developing bio-diversity in Changbaishan Biosphere Reserve.

Changbaishan Biosphere Reserve is one of the most important nature reserves in China. The main objectives of bio-diversity conservation in the Reserve is to protect nature and maintain natural processes in an undisturbed state. In order to have ecologically representative examples of natural environment available for scientific study, environmental monitoring, education, and maintaining genetic resources in a dynamic and evolutionary state, we should protect and utilize biological resources through the ways of not reducing gene and species diversity, not destroying the main habitats and ecosystems, ensuring the sustainable development of bio-diversity and realizing ecosystems' beneficial circulation, guaranteeing the richness of biodiversity, and bringing about the sustainable utilization of biological resources.

Geographical conditions

The Changbaishan Biosphere Reserve is located in Jilin Province of Northeastern China, 41°41'49"~42°25'18"N,

127°42'55"~128°16'48"E. It stretches along the boundary between China and Korea, and covers an area of 196,456 hm², with an elevation ranging from 500 to 2691 m above sea level.

The highest peak, Baiyunfeng is a magnificent volcano situated on the wide lava plateau. Within the crater, there is a beautiful lake, Tianchi, "Sky Lake", with an area of 9.4 km². There are many peaks round the lake, and the only gap is to the North, through which the Changbaishan waterfall runs out, falling 68 m to the valley below.

Changbaishan Biosphere Reserve has a typical mountain climate. The climate is characterized as cool temperate climate with a cold, long winter and a short, cool summer. Altitudinal belts of climate are distinct. The average annual temperature lies between 3-7°C, and annual precipitation is over 600 mm. In areas with relatively high altitude above sea level the annual precipitation is over 1400 mm, giving Changbaishan Mountains the greatest rainfall in northeastern China (Yang Meihua 1987).

Bio-diversity

Diversity of natural landscape belts

The Changbaishan Biosphere Reserve has a clearly defined vertical zones of vegetation. From foot to peak it runs as follows: mixed coniferous and broad-leaved forest, coniferous forest, Ermans birch forest, and alpine tundra (Bai Xiaoming, 1988).

Mixed coniferous and broad-leaved forest

From the river valley (altitude 600 m) to the gently sloping basalt tableland at the foot of the mountains with an altitude of 1100 m, the climate is warm and wet, and mixed broad-leaved Korean pine forests, the most representative type of regional vegetation of Changbai Mountain, is distributed there.

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Montane frigid-temperate coniferous forests.

From the upper limits of the mixed coniferous-broad-leaved forest zone to the main basalt tableland at an altitude of 1800 m, there is a marked drop in temperature and the air humidity is high, with cold winter and cool summers. By this point most of the thermophilic broad-leaved trees have disappeared and replaced by frigid temperate coniferous forests consisting of cold-resistant spruce and fir, which are well adapted to the brown forest soil. Korean pine is the prime component of the coniferous broad-leaved mixed forests.

Alpine krummholz.

As moving up from the frigid-temperate forest zone to an altitude of 2,100 m, there is a sharp incline in gradient, and the rise in altitude brings a steady drop in temperature and an increase in precipitation. Humidity is higher than in the other two forest zones, the wind force is stronger, and the soil is interspersed with large quantities of gravel. Tall conifers are unsuited for growth in so harsh an environment, and the sparse forests contain a poor selection of tree species, the dominant dwarf tree Ermans birch (*Betula ermanii*). As a fiend for strong sunlight and high humidity, Ermans birch can grow in almost any soil. In adapting to wind and snow, its branches form a dense miniature forest. Treacherous alpine gales force the branches to buckle and bend, distorting them into a peculiar flag-shaped tree canopy. These tangled trees lend a unique aspect to the subalpine Ermans birch forests.

Alpine tundra.

From the upper middle section of the volcanic cone at an altitude of 2,100 m right up to the mountain summit, there is a special drop in temperature and a steady increase in precipitation. The maximum annual precipitation measured was over 1400 mm. Snowfall accounts for a large part of the precipitation. The area is deep in snow for six months, measuring 90 to 115 cm at its deepest. Wind force generally stands at 7 degrees or over, with a fierce wind blowing practically the whole year round. Low temperatures, humidity, cloud, mist and wind are perennial features of the climate. This type of ecological environment bears close similarities to polar climates, and an alpine tundra zone the only one of its kind in the eastern Eurasian continent has developed.

Bio-diversity of plant and animal species*Plant resources*

Plant species in Changbaishan Biosphere Reserve are rich and abundant. Vascular plants involve about 1,400 species, belonging to 131 families and 480 genera. The lower plants are also very rich. The numbers of the species of various groups are given in Table 1.

The studies on plant resources of this region are far from being completed. Only a few plants have subjected detailed observation.

Animal Resources

Changbaishan Biosphere Reserve is close to the Japanese Sea and is influenced by monsoon. Its climate is relatively humid and mild, so fauna has the feature of south. Because the area lies at high latitude and is influenced by Siberia frigid temperate zone and polar region, some animal species which are characterized as northern or frigid zonal type range here as their southern boundary. Therefore, the components of fauna in this region are complex with numerous species (Table 2).

Table 1. Statistics of plant species in Changbaishan biosphere reserve

Categories	Orders	Families	Genera	Species
Fungi	15	37	131	430
Lichens	2	22	40	200
Sedge	2	16	22	36
Moss	12	31	80	154
Pteridophyte	7	19	34	80
Gymnosperm	2	3	8	11
Angiosperm	33	108	495	1,325
Total	73	234	810	2,277

Table 2. Statistics of animal species in Changbaishan biosphere reserve

Categories	Orders	Families	Species
Pests	6	48	387
Pest enemies	7	29	94
Cyclostomata	1	1	3
Fish	2	4	8
Amphibians	2	6	13
Reptiles	1	3	11
Birds	18	48	277
Mammals	6	19	58
Vertebrates	30	61	370
Total	73	219	1,221

The endangered or rare plant & animal species and the causes of biodiversity degradation**The endangered or rare plant and animal species**

The special factors of climate, topography and soil, etc. in Changbaishan Biosphere Reserve make it present complicated vegetation types with very rich plant and animal species. In the meantime, it has retained many rare and valuable animal and plant species, some have become endemic species and some of which are endangered or rare due to a variety of causes. Therefore, Changbaishan Biosphere Reserve has become a refuge for endangered and rare animals and plants in the northern region of China, and also an exceptional gene bank. The endangered or rare plant and animal species in Changbaishan Biosphere Reserve are showed in Table 3 (Bai Xiaoming, 1988; Fu Ligu, 1992):

Table 3 The endangered or rare plant and animal species in Changbaishan biosphere reserve

Endangered or rare plant species	National protected bird species	National protected beast species
<i>Boschniakia rossica</i>	<i>Ciconia ciconia boyciana</i>	<i>Panthera pardus japonensis</i>
<i>Malus kcmarovii</i>	<i>Ciconia nigra</i>	<i>Panthera tigris altaica</i>
<i>Panax ginseng</i>	<i>Mergus aquamatus</i>	<i>Cervus nippon</i>
<i>Rosa rugosa</i>	<i>Aquila h. heliaca</i>	<i>Ursus arctos</i>
<i>Chosenia arbutifolia</i>	<i>Grus japonensis</i>	<i>Selenarctos thibetanus</i>
<i>Empetrum nigrum</i> var. <i>japonicum</i>	<i>Cygnus c. cygnus</i>	<i>Lutra lutra</i>
<i>Phyllitis japonicus</i>	<i>Lyrurus tetrix ussuriensis</i>	<i>Martes zibellina</i>
<i>Acanthopanax senticosus</i>	<i>Tetrastes bonasia amurensis</i>	<i>Felis lnx</i>
<i>Astragalus membranaceus</i>	<i>Anthropoides virgo</i>	<i>Cervus elaphus xanthopygus</i>
<i>Fraxin mandshurica</i>	<i>Accipiter nisus nisosimilis</i>	<i>Moschus moschiferus</i>
<i>Fritiliaria ussuriensis</i>	<i>Accipiter gentilis schvedowi</i>	<i>Nummedus goral caudatus</i>
<i>Gasrodia elata</i>	<i>Pernis ptilorhynchus orientalis</i>	
<i>Glycine soja</i>	<i>Aquila chrysaetos kamtschatica</i>	
<i>Jaglan mandshurica</i>	<i>Aegypius monachus</i>	
<i>Magnolia sieboldii</i>	<i>Ninox scutulata ussuriensis</i>	
<i>Ophioglossum thermale</i>	<i>Strix uralensis coreensis</i>	
<i>Oplopanax elatus</i>	<i>Asio o. otus</i>	
<i>Phellodendron amurense</i>	<i>Asio f. flammeus</i>	
<i>Phyllocladus caerulea</i>		
<i>Pinus sylvestris</i> var. <i>sylvestriiformis</i>		
<i>Rhododendron chrysanthum</i>		
<i>Rhododendron redowskianum</i>		
<i>Salix polyadenia</i> var. <i>tschangbaishanica</i>		
<i>Thuja koraiensis</i>		

Causes of bio-diversity degradation

The degradation of bio-diversity is a worldwide problem and the causes of bio-diversity loss have been discussed in many publications. MaNeely Jeffery A. et al. (1990) indicated the following major threats to bio-diversity: (1) habitat alternation; (2) over harvesting; (3) chemical pollution; (4) climatic change; (5) introduced species; and (6) increase in population. A similar conclusion had been reached in the "Global Bio-diversity Strategy" prepared jointly by World Resources Institute (WRI). The World Conservation Union (IUCN) and United Nations Environmental Program (UNEP) (1992). It indicated that habitat loss and fragmentation, introduced species, over-exploitation of plant and animal species, pollution of soil, water, and atmosphere, global climate change and industrial agriculture and forestry are the major causes of the loss of bio-diversity. Today's threats to species and ecosystems are the greatest in the recorded history. Virtually all of them are caused by human mismanagement of biological resources, often stimulated by misguided economic policies and faulty institutions that enable the exploiters to avoid paying the full costs of their exploitation.

Historical review of the bio-diversity degradation

The bio-diversity degradation in Changbaishan Biosphere Reserve is closely connected with the bio-diversity degradation in the surrounding areas. The rich biological re-

sources have been seriously disturbed by human activities. About 3000a ago, a minority nationality, the Sushen, lived in Changbai Mountain area and was in close contact with people of central China. Historical record indicated that the first big scale exploitation of natural resources had occurred since 698 A.D during the Bohai dynasty. Fishing, hunting and animal husbandry were the main activities and people began to reclaim and cultivate land for agriculture in the river basins. Along with the development of agriculture production, people had to cut an increasing number of trees for building houses, making ships and for energy, but these activities didn't affect the stability and basic conditions of the forest ecosystems. However, at the end of the 19th century and during the Qing dynasty, when an administrative system was set up, land was being cultivated at an unprecedented rate. Almost all the river basins, flat lands and hillside fields were reclaimed for farmland, and forests were cut on a large scale. Relatively undisturbed ecosystems have shrunk dramatically in area over the past decades as human population and resource consumption has grown.

Major causes of bio-diversity loss

The major causes of bio-diversity loss in Changbai Mountain areas generally include 2 aspects: human influence and natural factors. Human influence are mainly as follows: the unsustainable high rate of human population growth and natural resources consumption in the surrounding area; unreasonable forest exploitation; over-

exploitation of economic wildlife; economic systems that fail to value the environment and its resources; the negative effects of tourism; human-caused forest fire; chemical pollution; climate change brought about by air pollution and the increase in atmospheric CO₂ due to deforestation and burning fossil fuels; scanty or insecure funds for management; and inadequate knowledge of natural ecosystems and their innumerable components. Natural factors that cause bio-diversity loss in Changbai Mountain area mainly include volcanic activities, forest fire and wind hazards, and natural selection.

The strategy for conservation and sustainable utilization of bio-diversity

The causes for bio-diversity loss are intricate and complex. Therefore, the approaches to solve the problem concern many aspects, which needs joint efforts of people from all institutions and various circles. The bio-diversity conservation in Changbaishan Biosphere Reserve must be planned closely connecting with the land management in surrounding area because the bio-diversity status in the Reserve can be seriously influenced by bio-diversity status in the surrounding areas. It is important to promote environmentally sound and sustainable development in areas adjacent to the Reserve. It is the combination of saving and sustainable utilization of bio-diversity, and the combination of saving, restoration and reconstruction of bio-diversity (Chen Lingzhi 1993, 1995; Jin Jianming and Dayuan Xue 1991).

The strategy for bio-diversity conservation

Wise policies-making and adjusting

The national policies often lead to the conservation or destruction of resources. Therefore, policy-making and adjusting should be the first approach for conservation. The legislation and national policies are directly connected with biological and natural resources of wild habitats, wild plants and animals, forests, etc. The policies also influence on bio-diversity through land tenure, rural development, family planning, industrial development and the exploitation and utilization techniques of food, pesticide, energy etc.

In Changbai Mountain areas, the government should develop the local policy frameworks that foster the sustainable use of biological resources and the maintenance of bio-diversity and apply it under effective control. The forestry policies that encourage resource degradation and the conversion of the valuable natural forest ecosystems to other less valuable uses should be abandoned. Sound timber plantation policy must avoid three particular traps: namely, no policy should promote the conversion of diverse natural forest to plantation; plantation should be sited only on already deforested and unproductive land; and no policy should promote the establishment of uninterrupted mono-cultural stands over large areas.

Protecting species and their habitats

Protected areas being the legally established sites managed for conservation objectives, are an essential means for saving bio-diversity. The conservation of species can be best realized through protecting habitats (WRI, 1990; Chen Lingzhi, 1994; Wang Xianpu, 1989, 1994). Changbai Mountain National Reserve, at present, is functioning as a conservation center of rare and endangered species in Changbai Mountain area. Now there are 24 rare or endangered plant species and 59 rare or endangered animal species in the reserve, among which the endemic species in Changbai Mountain area are all in the reserve. The reserve has undoubtedly played a very important role in conserving bio-diversity of the region as an *in situ* facility.

It is important to incorporate bio-diversity conservation with the uses of all land and resource, and harmonize bio-diversity conservation with local benefits.

Ex situ facilities

Ex situ facilities includes botanic gardens, aquarium, game farms, captive breeding programs in zoos, gene banks, etc. For some endangered species, *ex situ* approach is indispensable. *Ex situ* conservation programs supplement *in situ* conservation by providing for long-term storage, analysis, testing, and propagation of threatened and rare species of plants and animals and their progenies. They are particularly important for wild species whose populations are highly reduced in numbers, serving as a backup to *in situ* conservation, as a source of material for reintroduction, and as a major repository of genetic material for future breeding programs of domestic species. Some *ex situ* facilities--notably zoos and botanic gardens--also provide important opportunities for public education. Even for wild species that are not threatened, *ex situ* collections are needed to make the material readily available for breeding--breeders do not normally go out into the field for their material, though regular infusions from wild sources are required.

In conclusion, the contributions of *ex situ* to conservation are essential for ensuring the survival of wild species of plants and animals that have been reduced to very low levels in the wild. Of course *ex situ* approaches depend on *in situ* approaches to enable their genetic stocks to be replenished. Therefore, the two approaches should be considered as opposite ends of the total spectrum required for effective conservation.

A conscious relationship needs to be established between *in situ* and *ex situ* approaches to conservation and these methods need to be integrated within overall regional development.

Summarizing, upgrading and disseminating experiences and indigenous knowledge

Through centuries of living close to nature, local peoples have acquired an immense knowledge of their environment and its natural resources. Living in and on the richness and variety of complex ecosystems, they have an

understanding of the properties of plants and animals, the functioning of ecosystems and the particular and often detailed techniques for using and managing them. Surrounding Changbaishan Biosphere Reserve, local people rely on species for foods, medicines, fuel, building materials, and many other products. Meanwhile, the environmental knowledge and perception of the local people and their relationship with it are often important elements of cultural entity.

In terms of possible future action, scientists and management institutions should take steps to record and apply these indigenous knowledge in promoting participatory approaches to the management of natural resources and to the equitable and sustainable use of resources.

Carrying out scientific research, strengthening human capacity for conserving and using bio-diversity sustainable

Strengthening scientific and technological study and relying on scientific and technological progress are the necessary way to conserve bio-diversity. Low scientific and technological level often causes serious destruction and waste of biological resources. The techniques of conserving bio-diversity mainly include the following aspects: 1) the analysis of existing state, distribution, quantity, changing tendency and reduction causes of bio-diversity; 2) the technical study of conserving bio-diversity such as the study of in-situ and ex-situ techniques; and 3) the technological study of sustainable use of biological resources including the study of reasonable exploitation of biological resources and biotechniques.

Education reinforcement

Another approach is reinforcement of education. Through propaganda enhance the public knowledge, morality of conserving bio-diversity and the ability of associating themselves with conservation. Through special training, primary and middle school education and professional education roots bio-diversity protection a component of public knowledge system and enhance the specialized quality of managerial staff related to conserving bio-diversity and exploiters of biological resources.

The strategy for sustainable utilization of bio-diversity

The fundamental purpose of sustainable development is to meet the human needs, so sustainable utilization of biological resources is the developing trend of bio-diversity conservation (Luo Weizheng, 1995; Qian Yingqian, 1995, 1994; Rao Jiteng, 1995). In order to conserve bio-diversity and sustainably and reasonably utilize natural resources in Changbaishan Biosphere Reserve, the following strategies are recommended.

(1) Strengthening research especially researches on endangered or rare plant and animal species.

According to estimation, the extinct speed of vertebrates on earth averaged 90 species each century prior to the human civilization. But after industrialization, as mankind has overused the natural resources, species on earth

have become extinct at an amazing speed. During the coming years about 5,000 species will become extinct each year (Myers, 1976). The fundamental researches are extremely necessary, otherwise many species probably will have disappeared before people can know them.

(2) Controlling human population

The control of human population is the main content of bio-diversity conservation. In the past, there was less population in Changbaishan Mountain areas, which are the key areas for conservation. For example, Antu County is within the Changbaishan Biosphere Reserve with a population below 10,000 in 1927, only 69,724 in 1958 and 207,000 today (Luo Weizheng et al. 1995). The soaring increase of human population has put great pressure on natural ecosystems. When the human population density exceeds 20 people per km², *Panthera tigris altaica* will disappear, but the human population density in Antu County today has reached 29 people per km². Therefore, it is unavoidable for *Panthera tigris altaica* to disappear under such high population pressure.

(3) Accelerating economic development and alleviating poverty.

Accelerating economic development and alleviating poverty are the guarantee for conserving biodiversity (Luo Weizheng et al, 1995; Dai Xingquan, 1995). Poverty is the basic cause that led to bio-diversity degradation because people must survive first. As they become richer and richer, they will ask for better environment. At present, the developed countries and regions has entered the stage of ecological modernization in economic structure, but great majority of countries with bumper bio-diversity are developing countries. In these countries, the increase of national incomes is realized at the costs of destroying their primary forests and lowering bio-diversity. So accelerating economic development and alleviating poverty is crucial to the conservation of bio-diversity.

(4) Accelerating urbanization

Accelerating urbanization and returning more land to nature can better conserve bio-diversity. Since China has practiced reform and open-door policies, China's economy has developed rapidly, but she is still very backward compared with developed countries. Especially, agricultural population possesses a greater proportion and many districts almost have no habitats for wild animals. One of the approaches for conserving bio-diversity as well as promoting economic development is the acceleration of urbanization, which can concentrate population and realize bio-diversity conservation for sustainable development in extensive area at the cost of bio-diversity loss in a limited area.

(5) Suiting policies and regulations for sustainable development

Policies and regulations should be suitable for the sustainable development of bio-diversity. Traditional economic policies didn't consider the damage of bio-diversity loss. For example, when a hunter goes hunting,

the games' price are only linked with market demand and labor input; when resources decrease, market price will rise, which accelerates resources' reduction and ultimately leads to the extinction of population. Therefore, for economic activities, the government must consider the sustainable utilization of biological resources and encourage the conservation of bio-diversity.

(6) Enhancing the national quality by strengthening propaganda and education. Wildlife resources belong to the whole mankind. But, when one goes hunting or collects wild plants, he just treat this as making a living. Moreover, the effects of industry on environment have only been evaluated in recent years. So, the conservation task only can progress forward through the mankind's recognition of the importance of wildlife conservation. The government should use Reserves, Zoos, Botanical gardens, Aquariums and Museums as educational media and enhance the whole nation's quality. Only in this way the conservation become possible.

In conclusion, people have begun to recognize that bio-diversity conservation is not just a task of biologists, which can has serious impacts on economic development, social stability and mankind future. The endeavor of biologists only provides fundamental data for bio-diversity conservation, the realization of bio-diversity conservation depends on national policies, economic development, social stability and national quality.

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References

- Bai Xiaoming. 1988. The exploitation of natural resources and protection of ecological environment in Changbaishan Mountain Region. Changchun: Jilin Science and Technology Press, (in Chinese)
- Chen Lingzhi et al. 1993. Bio-diversity in China: the existing situation and the strategy for protection. Chinese Science and Technology Press, (in Chinese)
- Chen Lingzhi. 1995. The main types of vegetation and the protection strategy in China. In: Advance of Biodiversity Study. Beijing: Chinese Science and Technology Press, 296~302(in Chinese)
- Dai Xingquan. 1995. An approach to the protection of biological diversity. In: Advance of Biodiversity Study. Beijing: Chinese Science and Technology Press, 64~69 (in Chinese)
- Fu Ligu. 1992. Red cover book for plants in China: Endangered and rare plants (1). Beijing: Chinese Science and Technology Press, (in Chinese)
- Jin Jianming and Dayuan Xue. 1991. Biodiversity and its conservation strategy in China. Rural ecological environment. (2): 1~5
- Luo Weizheng and Zhijie Yang et al. 1995. Conservation of biodiversity and strategy of its sustainable development. In: Advance of Biodiversity Study. Beijing: Chinese Science and Technology Press, 76~81(in Chinese)
- Qian Yingqian and Keping Ma et al. 1994. The Principle and Methods of Biodiversity Study. Beijing: Chinese Science and Technology Press, (in Chinese).
- Qian Yingqian and Ma Keping. 1995. On the issues related to conservation and sustainable use of biodiversity in China. In: Advance of Biodiversity Study. Beijing: Chinese Science and Technology Press, 15~23 (in Chinese)
- Qian Yingqian. 1995. Advances in bio-diversity research. Beijing: Chinese Science and Technology Press, (in Chinese)
- Rao Jiteng and Li Shitong. 1995. Bio-diversity conservation and its sustainable use in Chebaling Nature Reserve. In: Advance of Biodiversity Study. Beijing: Chinese Science and Technology Press, 390~395(in Chinese)
- Wang Xianpu et al. 1994. The principle and practice of Biodiversity. Chinese Environmental Science and Technology Press
- Wang Xianpu. 1989. The theory and practice of nature reserves. Beijing: Chinese Environmental Science and Technology Press

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